LIFE AND MIND

BY JOHN BURROUGHS

I

THERE are three kinds of change in the world in which we live—physical and mechanical change which goes on in time and place among the tangible bodies about us, chemical change which goes on in the world of hidden molecules and atoms of which bodies are composed, and vital change which involves the two former, but which also involves the mysterious principle or activity which we call life. Life comes and goes, but the physical and chemical orders remain. The vegetable and animal kingdoms wax and wane, or disappear entirely, but the physico-chemical forces are as indestructible as matter itself. This fugitive and evanescent character of life, the way it uses and triumphs over the material forces, setting up new chemical activities in matter, sweeping over the land areas of the earth like a conflagration, lifting the inorganic elements up into myriads of changing and beautiful forms, instituting a vast number of new chemical processes and compounds, defying the laboratory to reproduce it or kindle its least spark—a flame that cannot exist without carbon and oxygen, but of which carbon and oxygen do not hold the secret, a fire reversed, building up instead of pulling down, in the vegetable with power to absorb and transmute the inorganic elements into leaves and fruit and tissue; in the animal with power to change the vegetable products into bone and muscle and nerve and brain, and finally into thought and consciousness—run by the solar energy and dependent upon it, yet involving something which the sunlight cannot give us—in short, an activity in matter, or in a limited part of matter, as real as the physico-chemical activity, but, unlike it, defying all analysis and explanation and all our attempts at synthesis. It is this character of life, I say, that so easily leads us to look upon

it as something *ab extra,* or superadded to matter, and not an evolution from it. It has led Sir Oliver Lodge to conceive of life as a distinct entity, existing independent of matter, and it is this conception that gives the key to Henri Bergson's wonderful book, *Creative Evolution.*

There is possibly or probably a fourth change in matter, physical in its nature, but much more subtle and mysterious than any of the physical changes which our senses reveal to us. I refer to radioactive change, or to the atomic transformation of one element into another, such as the change of radium into helium, and the change of helium into lead—a subject that takes us to the borderland between physics and chemistry where is still debatable ground.

I began by saying that there were three kinds of changes in matter—the physical, the chemical, and the vital. But if we follow up this idea and declare that there are three kinds of force also, claiming this distinction for the third term of our proposition, we should be running counter to the main current of recent biological science. " The idea that a peculiar ' vital force ' acts in the chemistry of life," says Professor Soddy, " is extinct."

"Only chemical and physical agents influence the vital processes," says Professor Czapek of the University of Prague, " and we need no longer take refuge in mysterious ' vital forces ' when we want to explain these."

Tyndall was obliged to think of a force that guided the molecules of matter into the special form of a tree. This force was in the ultimate particles of matter. But when he came to the brain and to consciousness, he says, a new product appears that defies mechanical treatment.

The attempt of the biological science of our time to wipe out all distinctions between the living and the non-living, solely because scientific analysis reveals no difference, is a curious and interesting phenomenon. The French biologist, Professor Le Dantec of the Sorbonne, in his volume on *The Nature and Origin of Life,* sees no more difference between inert and animate matter than between two chemical compounds, one with two less atoms of hydrogen in its composition than the other.

Professor Schäffer, in his presidential address before the British Association in 1912, argues that all the main characteristics of living matter, such as assimilation and disassimilation, growth and reproduction, spontaneous and amœboid

movement, osmotic pressure, karyokinesis, etc., were equally apparent in the non-living; therefore he concluded that life is only one of the many chemical reactions, and that it is not improbable that it will yet be produced by chemical synthesis in the laboratory. The logic of the position taken by Professor Schäffer and of the school to which he belongs, demands this artificial production of life—an achievement that seems no nearer than it did a half century ago. When it has been attained, the problem will be simplified, but the mystery of life will by no means have been cleared up. One follows these later bio-chemists in working out their problem of the genesis of life with keen interest, but always with a feeling that there is more in their conclusions than is justified by their premises. I for my own part am not looking for an appeal to any teleological factor or principal in nature. I am convinced that whatever is, is natural, but I feel the need of something of a different order from the spark evoked by the flint and the steel, or the reaction of chemical compounds, though if asked to explain what this something is that is characteristic of living matter, I should be hard put for an answer.

The new school of biologists start with matter that possesses extraordinary properties—with matter that seems inspired with the desire for life, and behaving in a way that it never will behave in the laboratory. They begin with the earth's surface warm and moist, the atmosphere saturated with watery vapor and carbon dioxide and many other complex unstable compounds; there they summon all the material elements of life—carbon, oxygen, hydrogen, and nitrogen, with a little sodium, chlorine, iron, sulphur, phosphorus, and others—and make these run together to form a jelly-like body called a colloid; then they endow this jelly mass with the power of growth, and of subdivision when it gets too large; they make it able to absorb various unstable compounds from the air, giving it internal stores of energy, "the setting free of which would cause automatic movements in the lump of jelly." Thus they lay the foundations of life. This carbonaceous material with properties of movement and subdivision due to mechanical and physical forces is the immediate ancestor of the first imaginary living being, the *protobion*. To get this *protobion* the chemists summon a reagent known as catalyser. The catalyser works its magic on the jelly mass. It sets up a wonderful reaction

by its mere presence, without parting with any of its substance. Thus a bit of platinum which has this catalytic power is dropped into a vessel containing a mixture of oxygen and hydrogen; the two gases instantly unite and form water. A catalyser introduced in the primordial jelly liberates energy and gives the substance power to break up the various complex unstable compounds into food, and promote growth and subdivision. In fact, it awakens or imparts a vital force and leads to " indefinite increase, subdivision, and movement."

With Professor Schäffer there is first " the fortuitous production of life upon this globe "—the chance meeting or jostling of the elements that resulted in a bit of living protoplasm, " or a mass of colloid slime " in the old seas, or on their shores, " possessing the property of assimilation and therefore of growth." Here the whole mystery is swallowed at one gulp. " Reproduction would follow as a matter of course," because all material of this physical nature—fluid or semi-fluid in character—" has a tendency to undergo subdivision when its bulk exceeds a certain size."

" A mass of colloidal slime " that has the power of assimilation and of growth and reproduction, is certainly a new thing in the world, and no chemical analysis of it can clear up the mystery. It is easy enough to produce colloidal slime, but to endow it with these wonderful powers so that " the promise and the potency of all terrestrial life " slumbers in it is a staggering proposition.

Whatever the character of this subdivision, whether into equal parts or in the form of buds,

> every separate part would resemble the parent in chemical and physical properties, and would equally possess the property of taking in and assimilating suitable material from its liquid environment, growing in bulk and reproducing its like by subdivision. In this way from any beginning of living material a primitive form of life would spread and would gradually people the globe. The establishment of life being once effected, all forms of organization follow under the inevitable laws of evolution.

Why all forms of organization—why the body and brain of man—must inevitably follow from the primitive bit of living matter, is just the question upon which we want light. The proposition begs the question. Certainly when you have got the evolutionary process once started in matter which has these wonderful powers, all is easy. The pro-

fessor simply describes what has taken place and seems to think that the mystery is thereby cleared up, as if by naming all the parts of a machine and their relation to one another, the machine is accounted for. What caused the iron and steel and wood of the machine to take this special form, while in other cases the iron and steel and wood took other radically different forms, and vast quantities of these substances took no form at all?

In working out the evolution of living forms by the aid of the blind physical and chemical agents alone, Professor Schäffer unconsciously ascribes the power of choice and purpose to the individual cells, as when he says that the cells of the external layer sink below the surface for better protection and better nutrition. It seems to have been a matter of choice or will that the cells developed a nervous system in the animal and not in the vegetable. Man came because a few cells in some early form of life acquired a slightly greater tendency to react to an external stimulus. In this way they were brought into closer touch with the outer world and thereby gained the lead of their duller neighbor cells, and became the real rulers of the body, and developed the mind.

One reads Professor Schäffer's address with a peculiar feeling of admiration and bewilderment—admiration for its lucidity, its physiological science, and the logical texture of the argument, and bewilderment on having it urged upon him by so competent a mind that at bottom there is no fundamental difference between the living and non-living. We need not urge the existence of a peculiar vital force, as distinct from all other forces, but all distinctions between things are useless if we cannot say that a new behavior is set up in matter which we describe by the word "vital," and that a new principle is operative in organized matter which we must call "intelligence." Of course all movements and processes of living beings are in conformity with the general laws of matter, but does such a statement necessarily rule out all idea of the operation of an organizing and directing principle that is not operative in the world of inanimate things?

In this philosophy evolution is purely a mechanical process—there is no inborn tendency, no inherent push, no organizing effort, as Bergson urges, but all results from the blind groping and chance jostling of the inorganic elements;

from the molecules of undifferentiated protoplasm to the brain of a Christ or a Plato, is just one series of unintelligent physical and chemical activities in matter.

May we not say that all the marks or characteristics of a living body which distinguish it in our experience from an inanimate body, are of a non-scientific character, or outside the sphere of experimental science? We recognize them as readily as we distinguish day from night, but we cannot describe them in the fixed terms of science. When we say growth, metabolism, osmosis, the colloidal state, science points out that all this may be affirmed of inorganic bodies. When we say a life principle, a vital force or soul or spirit or intelligence, science turns a deaf ear.

The difference between the living and the non-living is not so much a physical difference as a metaphysical difference. Living matter is actuated by intelligence. Its activities are spontaneous and self-directing. The rock, and the tree that grows beside it, and the insects and rodents that burrow under it, may all be made of one stuff, but their difference to the beholder is fundamental; there is an intelligent activity in the one that is not in the other. Now no scientific analysis of a body will reveal the secret of this activity. As well might your analysis of a phonographic record hope to disclose a sonata of Beethoven latent in the waving lines. No power of chemistry could reveal any difference between the gray matter of Plato's brain and that of the humblest citizen of Athens. All the difference between man, all that makes a man a man, and an ox an ox, is beyond the reach of any of your physico-chemical tests. By the same token the gulf that separates the organic from the inorganic is not within the power of science to disclose. The biochemist is bound to put life in the category of the material forces because his science can deal with no other. To him the word " vital " is a word merely, it stands for no reality, and the secret of life is merely a chemical reaction. A living body awakens a train of ideas in our minds that a non-living fails to awaken —a train of ideas that belong to another order from that awakened by scientific demonstration. We cannot blame science for ruling out that which it cannot touch with its analysis, or repeat with its synthesis. The phenomena of life are as obvious to us as anything in the world; we know their signs and ways, and witness their power, yet in the

alembic of our science they turn out to be only physico-chemical processes; hence that is all there is of them. Vitality, says Huxley, has no more reality than the horology of a clock. Yet Huxley sees three equal realities in the universe — matter, energy, and consciousness. But consciousness is the crown of a vital process. Hence it would seem as if there must be something more real in vitality than Huxley is willing to admit.

II

Nearly all the later biologists or biological philosophers are as shy of the term " vital force," and even of the word " vitality," as they are of the words " soul," " spirit," " intelligence," when discussing natural phenomena. To experimental science such words have no meaning because the supposed realities for which they stand are quite beyond the reach of scientific analysis. Sir Ray Lankaster in his *Science from an Easy Chair* compares vitality with aqueosity, and says that to have recourse to a vital principle or force to explain a living body is no better philosophy than to appeal to a principle of aqueosity to explain water. Of course words are words, and they have such weight with us that when we have got a name for a thing it is very easy to persuade ourselves that the thing exists. The terms " vitality," " vital force," have long been in use, and it is not easy to convince oneself that they stand for no reality. Certain it is that living and non-living matter are sharply separated, though when reduced to their chemical constituents in the laboratory they are found to be identical. The carbon, the hydrogen, the nitrogen, the oxygen, and the lime, sulphur, iron, etc., in a living body are in no way peculiar, but are the same as these elements in the rocks and the soil. We are all made of one stuff; a man and his dog are made of one stuff; an oak and a pine are made of one stuff; Jew and Gentile are made of one stuff. Should we be justified, then, in saying that there is no difference between them? There is certainly a moral and an intellectual difference between a man and his dog, if there is no chemical and mechanical difference. And there is as certainly as wide or a wider difference between living and non-living matter, though it be beyond the reach of science to detect. For this difference we have to have a name, and we use the words " vital," " vitality," which seem to me to stand for as un-

deniable realities as the words heat, light, chemical affinity, gravitation. There is not a principle of roundness, though "nature centers into balls," nor of squareness, though crystallization is in right lines, nor of aqueosity, though two-thirds of the surface of the earth is covered with water. Can we on any better philosophical grounds say that there is a principle of vitality, though the earth swarms with living beings? Yet the word vitality stands for a reality, it stands for a peculiar activity in matter—for certain movements and characteristics for which we have no other term. I fail to see any analogy between aqueosity and that condition of matter we call vital or living. Aqueosity is not an activity, it is a property, the property of wetness; viscosity is a term to describe other conditions of matter; solidity, to describe still another condition; and opacity and transparency, to describe still others—as they affect another of our senses. But the vital activity in matter is a concrete reality. With it there goes the organizing tendency or impulse, and upon it hinges the whole evolutionary movement of the biological history of the globe. We can do all sorts of things with water—freeze it, boil it, evaporate it—and still keep its aqueosity. If we resolve it into its constituent gases we destroy its aqueosity, but by uniting these gases chemically we have the wetness back again. But if a body loses its vitality, its life, can we by the power of chemistry, or any other power within our reach, bring the vitality back to it? Can we make the dead live? You may bray your living body is a mortar, destroy every one of its myriad cells, and yet you may not extinguish the last spark of life; the protoplasm is still living. But boil it or bake it and the vitality is gone, and all the art and science of mankind cannot bring it back again. Of course life is dependent at all times upon the physical and chemical properties of the matter with which it is associated, but do these properties or activities tell the whole story about a living body? The physical and chemical activities remain after the vital activities have ceased. Do we not then have to supply a non-chemical, a non-physical force or factor to account for the living body? Is there no difference between the growth of a plant or an animal, and the increase in size of a sand-bank or a snow-bank, or a river delta? or between the wear and repair of a working-man's body and the wear and repair of the machine he drives? Excretion and secretion are not in the same

categories. The living and the non-living mark off the two grand divisions of matter in the world in which we live, as no two terms merely descriptive of chemical and physical phenomena ever can. Life is a motion in matter, but of another order from that of the physico-chemical, though inseparable from it. We may forego the convenient term "vital force." Modern science shies at the term "force." We must have force or energy or pressure of some kind to lift dead matter up into the myriad forms of life, though in the last analysis of it it may all date from the sun. When it builds a living body, we call it a vital force; when it builds a gravel-bank, or moves a glacier, we call it a mechanical force; when it writes a poem or composes a symphony, we call it a psychic force—all distinctions which we cannot well dispense with, though of the ultimate reality for which these terms stand we can know little. In the latest science heat and light are not substances, though electricity is. They are peculiar motions in matter which give rise to sensations in certain living bodies that we name light and heat, as another peculiar motion in matter gives rise to a sensation we call sound. Life is another kind of motion in certain aggregates of matter—more mysterious or inexplicable than all others because it cannot be described in terms of the others, and because it defies the art and science of man to reproduce.

Though the concepts "vital force" and "life principle" have no standing in the court of modern biological science, it is interesting to observe how often recourse is had by biological writers to terms that embody the same idea. Thus the German physiologist, Verworn, the determined enemy of the old conception of life, in his great work on *Irritability,* has recourse to "the specific energy of living substances." One is forced to believe that without this "specific energy" his "living substances" would never have arisen out of the non-living.

Professor Moore of Liverpool University, while discussing the term "vital force," invents a new phrase, "biotic energy," to explain the same phenomena. Surely a force by any other name is no more and no less potent. Both Verworn and Moore feel the need, as we all do, of some term, or terms, by which to explain that activity in matter which we call vital. Other writers have referred to "a peculiar power of synthesis" in plants and animals, which the inanimate forms do not possess.

Sir Ray Lankester, to whom I have already referred in discussing this subject, helps himself out by inventing, not a new force, but a new substance in which he fancies "resides the peculiar property of living matter." He calls this hypothetical substance "plasmogen," and thinks of it as an ultimate chemical compound hidden in protoplasm. Has this "ultimate molecule of life" any more scientific or philosophical validity than the old conception of a vital force? It looks very much like another name for the same thing—an attempt to give the mind something to take hold of in dealing with the mystery of living things. This imaginary "life-stuff" of the British scientist is entirely beyond the reach of chemical analysis; no man has ever seen it or proved its existence. In fact it is simply an invention of Sir Ray Lankester to fill a break in the sequence of observed phenomena. Something seems to possess the power of starting or kindling that organizing activity in a living body, and it seems to me it matters little whether we call it "plasmogen," or a "life principle," or "biotic energy," or what not; it surely leavens the loaf. Matter takes on new activities under its influence. Lankester thinks his plasmogen came into being in early geologic ages, and that the conditions which led to its formation have probably never recurred. Whether he thinks its formation was merely a chance hit or not, he does not say.

We see matter all about us, acted upon by the mechanico-chemical forces, that never takes on any of the distinctive phenomena of living bodies. Yet Verworn is convinced that if we could bring the elements of a living body together as Nature does, in the same order and proportion, and combine them in the selfsame way, or bring about the vital conditions, a living being would result. Undoubtedly. It amounts to saying that if we had Nature's power we could do what she does. *If* we could marry the elements as she does, and bless the banns as she seems to, we could build a man out of a clay-bank. But clearly physics and chemistry alone, as we know and practise them, are not equal to the task.

III

One of the fundamental characteristics of life is power of adaptation; it will adapt itself to almost any condition; it is willing and accommodating. It is like a stream that can be turned into various channels; the gall insects turn it into

channels to suit their ends when they sting the leaf of a tree or the stalk of a plant, and deposit an egg in the wound. " Build me a home and a nursery for my young," says the insect. " With all my heart," says the leaf, and forthwith forgets its function as a leaf, and proceeds to build up a structure, often of great delicacy and complexity, to house and cradle its enemy. The current of life flows on blindly and takes any form imposed upon it. But in the case of the vegetable galls it takes life to control life. Man cannot produce these galls by artificial means. But we can take various mechanical and chemical liberties with embryonic animal life in its lower sea-forms. Professor Loeb has fertilized the eggs of sea-urchins by artificial means: The eggs of certain forms may be made to produce twins by altering the constitution of the sea-water, and the twins can be made to grow together so as to produce monstrosities by another chemical change in the sea-water. The eyes of certain fish embryos may be fused into a single cyclopean eye by adding magnesium chloride to the water in which they live. Loeb says, " It is *a priori* obvious that an unlimited number of pathological variations might be produced by a variation in the concentration and constitution of the sea-water, and experience confirms this statement." It has been found that when frog's eggs are turned upside down and compressed between two glass plates for a number of hours, some of the eggs give rise to twins. Professor Morgan found that if he destroyed half of a frog's egg after the first segmentation, the remaining half gave rise to half an embryo, but that if he put the half-egg upside down, and compressed it between two glass plates, he got a perfect embryo frog of half the normal size. Such things show how plastic and adaptive life is. Dr. Carrel's experiments with living animal tissue immersed in a proper mother-liquid illustrates how the vital process—cell multiplication—may be induced to go on and on, blindly, aimlessly, for an almost indefinite time. The cells multiply, but they do not organize themselves into a constructive community and build an organ or any purposeful part. They may be likened to a lot of blind masons piling up brick and mortar without any architect to direct their work or furnish them a plan. A living body of the higher type is not merely an association of cells; it is an association and co-operation of communities of cells, each community working to a definite end and building an har-

monious whole. The biochemist who would produce life in the laboratory has before him the problem of compounding matter charged with this organizing tendency or power, and doubtless if he ever should evoke this mysterious process through his chemical reactions, it would possess this power, as this is what distinguishes the organic from the inorganic.

I do not see mind or intelligence in the inorganic world in the sense in which I see it in the organic. In the heavens one sees power, vastness, sublimity, unspeakable, but one sees only the physical laws working on a grander scale than on the earth. Celestial mechanics do not differ from terrestrial mechanics, however tremendous and imposing the result of their activities. But in the humblest living thing—in a spear of grass by the roadside, in a gnat, in a flea—there lurks a greater mystery. In an animate body, however small, there abides something of which we get no trace in the vast reaches of astronomy, a kind of activity that is incalculable, indeterminate, and super-mechanical, not lawless, but making its own laws, and escaping from the iron necessity that rules in the inorganic world.

Our mathematics and our science can break into the circle of the celestial and the terrestrial forces, and weigh and measure and separate them, and in a degree understand them; but the forces of life defy our analysis as well as our synthesis.

Knowing as we do all the elements that make up the body and brain of a man, all the physiological processes, and all the relations and interdependence of his various organs, and if, in addition, we knew all his inheritances, his whole ancestry back to the primordial cells from which he sprang, and if we also knew that of every person with whom he comes in contact and who influences his life, could we forecast his future, predict the orbit in which his life would revolve, indicate its eclipses, its perturbations, and the like, as we do that of an astronomic body? or could we foresee his affinities and combinations as we do that of a chemical body? Had we known any of the animal forms in his line of ascent, could we have foretold man as we know him to-day? Could we have foretold the future of any form of life from its remote beginnings? Would our mathematics and our chemistry have been of any avail in our dealing with such a problem? Biology is not in the same category with geology and astronomy. In the inorganic world, chemical

affinity builds up and pulls down. It integrates the rocks and, under changed conditions, it disintegrates them. In the organic world chemical affinity is equally active, but it plays a subordinate part. It neither builds up nor pulls down. Vital activities, if we must shun the term "vital force," do both. Barring accidents, the life of all organism is terminated by other organisms—micro-organisms and their bodies reduced to dust by the same agents. In the order of nature, life destroys life, and compounds destroy compounds. When the air and soil and water hold no invisible living germs, organic bodies never decay. It is not the heat that sets putrefaction, but germs in the air. Sufficient heat kills the germs, but what disintegrates the germs and reduces them to dust? Other still smaller organisms? and so on *ad infinitum?* Does the sequence of life have no end? The destruction of one chemical compound means the formation of other chemical compounds; chemical affinity cannot be annulled, but the activity we call vital is easily arrested. A living body can be killed, but a chemical body can only be changed into another chemical body. As we said we can do all sorts of things with water—freeze it, vaporize it, and separate it into its constituent gases, oxygen and hydrogen—but we cannot destroy the essential activity of its elements, as we can those of a living body.

The least of living things, I repeat, holds a more profound mystery than all our astronomy and our geology hold. It introduces us to activities which our mathematics do not help us to deal with. Our science can describe the processes of a living body, and name all the material elements that enter into it, but it cannot tell us in what the peculiar activity consists, or just what it is that differentiates living matter from non-living. Its analysis reveals no difference. But this difference consists in something beyond the reach of chemistry and of physics; it is active intelligence, the power of self-direction, of self-adjustment, of self-maintenance, of adapting means to an end. It is notorious that the hand cannot always cover the flea; this atom has will, and knows the road to safety. Behold what our bodies know over and above what we know. There is a chemist at work in the body who proceeds precisely like the chemist in his laboratory; they might both have graduated at the same school. Thus the chemist in the laboratory is accustomed to dissolve the substance which is to be used in an experiment to react

on other substances. The chemical course in living cells is the same. All substances destined for reactions are first dissolved. No compound is taken up in living cells before it is dissolved. Digestion is essentially identical with dissolving or bringing into a liquid state. On the other hand, when the chemist wishes to preserve a living substance from chemical change, he transfers it from a state of solution into a solid state. The chemist in the living body does the same thing. Substances which are to be stored up, such as starch, fat, or protein bodies, are deposited in insoluble form, ready to be dissolved and used whenever wanted for the life processes. Poisonous substances are eliminated from living bodies by the same process of precipitation. Oxalic acid is a product of oxidation in living cells, and has strong poisonous properties. To get rid of it, the chemist inside the body, by the aid of calcium salts, forms insoluble compounds of it, and thus casts it out. To separate substances from each other by filtration, or by shaking with suitable liquids, is one of the daily tasks of the chemist. Analogous processes occur regularly in living cells. Again, when the chemist wishes to finish his filtration quickly, he uses filters which have a large surface. "In living protoplasms, this condition is very well fulfilled by the foam-like structure which affords an immense surface in a very small space." In the laboratory the chemist mixes his substances by stirring. The body chemist achieves the same result by the streaming of protoplasm. The cells know what they want, and how to attain it, as clearly as the chemist does. The intelligence of the living body, or what we must call such for want of a better term, is shown in scores of ways—by the means it takes to protect itself against microbes, by the anti-toxins that it forms. Indeed, if we knew all that our bodies know, what mysteries would be revealed to us!

Life goes up-stream—goes against the tendency to a static equilibrium in matter; decay and death go down. What is it in the body that struggles against poisons and seeks to neutralize their effects? What is it that protects the body against a second attack of certain diseases, making it immune? Chemical changes, undoubtedly, but what brings about the chemical changes? The body is a *colony* of living units called cells, that behaves much like a colony of insects when it takes measures to protect itself against its enemies. The body forms anti-toxins when it has to. It

knows how to do it as well as bees know how to ventilate the hive, or how to seal up or entomb the grub of an invading moth. Indeed, how much the act of the body, in encysting a bullet in its tissues, is like the act of the bees in encasing with wax a worm in the combs!

What is that in the body which at great altitudes increases the number of red corpuscles in the blood, those oxygen-bearers, so as to make up for the lessened amount of oxygen breathed by reason of the rarity of the air? Under such conditions, the amount of hemaglobin is almost doubled. I do not call this thing a force; I call it an intelligence—the intelligence that pervades the body and all animate nature, and does the right thing at the right time. We no doubt speak too loosely of it when we say that it prompts or causes the body to do this, or to do that; it *is* the body; the relation of the two has no human analogy; the two are one.

On the threshold of the world of living organisms stands that wonderful minute body, the cell, the unit of life—a piece of self-regulating and self-renewing mechanism that holds the key to all the myriads of living forms that fill the world, from the amœba up to man. For chemistry to produce the cell is apparently as impossible as for it to produce a bird's egg, or a living flower, or the heart and brain of man. The body is a communal state made up of myriads of cells that all work together to build up and keep going the human personality. There is the same cooperation and division of labor that takes place in the civic state, and in certain insect communities. As in the social and political organism, thousands of the citizen cells die every day and new cells of the same kind take their place. Or, it is like an army in battle being constantly recruited—as fast as a soldier falls another takes his place, till the whole army is changed, and yet remains the same. The waste is greatest at the surface of the body through the skin, and through the stomach and lungs. The worker cells, namely, the tissue cells, like the worker bees in the hive, pass away the most rapidly; then, according to Haeckel, there are certain constants, certain cells that remain throughout life. "There is always a solid groundwork of conservative cells, the descendants of which secure the further regeneration." The traditions of the state are kept up by the citizen-cells that remain, so that, though all is changed in time, the genius

of the state remains; the individuality of the man is not lost. "The sense of personal identity is maintained across the flight of molecules," just as it is maintained in the state or nation, by the units that remain, and by the established order. There is an unwritten constitution, a spirit that governs, like Maeterlinck's "spirit of the hive." The traditions of the body are handed down from mother cell to daughter cell, though just what that means in terms of physiology or metabolism I do not know. But this we know —that you are you and I am I, and that human life and personality can never be fully explained or accounted for in terms of the material forces.

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